REMR Technical Note CS-MR-8.7

CASE HISTORY OF MONOLITH JOINT REPAIRS: Lock No. 2, Mississippi River

PURPOSE: To present a case history of monolith joint repairs in a navigation lock.

BACKGROUND: Lock and Dam No. 2 is located on the Mississippi River upstream from Hastings, Minnesota. The structure consists of a concrete dam, two locks, and an earth dike. The landward lock is 110 ft wide and 600 ft long with a 12-ft lift. The riverward lock is no longer used. The concrete in the lock walls contains 423 lb/cu yd of cement, with 2-in.-maximum-size aggregate and 0.55 water-cement ratio. The concrete is not air-entrained. Testing of several 6 in. cores taken in 1984 indicated an average compressive strength ranging from 6,130 to 8,080 psi.

SPALLING: In 1985, the only significant concrete deterioration in the landward chamber was spalling at the vertical monolith joints (Ref. a). This spalling was moderate to heavy and extended from approximately 2 ft below the lower pool elevation to the top of the lock wall (Fig. 1). The joints with a southern exposure showed the most deterioration, attributable to an increased number of cycles of freezing and thawing.

REPAIR SELECTION: In 1984, a major rehabilitation effort was initiated with the intention of extending the service life of the structure for another 50 years. A contractor prepared a design-analysis report for the concrete and wall-armor repairs (Ref. b). Four alternatives for repair of the deteriorated monolith joints were evaluated on the following bases: Cost, resistance to cycles of freezing and thawing, and resistance to damage from impact. The alternative selected as the optimum repair design (Fig. 2) was to include the following: On either side of the joint, a saw cut of at least 4 in. would be made and the deteriorated concrete removed. Then, anchors would be installed and a glass-fiber-reinforced-polymer-modified concrete would be placed in such a manner as to result in a recessed joint.

Fiber-reinforced-acrylic-polymer-modified concrete (FRAPMC) was chosen as the repair material because of its reported high performance based on the following criteria:

- Compatibility with existing materials
- Bonding properties
- Strength
- Vapor transmission
- Durability
- Low shrinkage potential
- Cost

REPAIRS: Twenty-eight vertical monolith joints were repaired when the lock was dewatered during the winter of 1986-87 (Ref. c and d).

Figure 1. Typical monolith joint deterioration

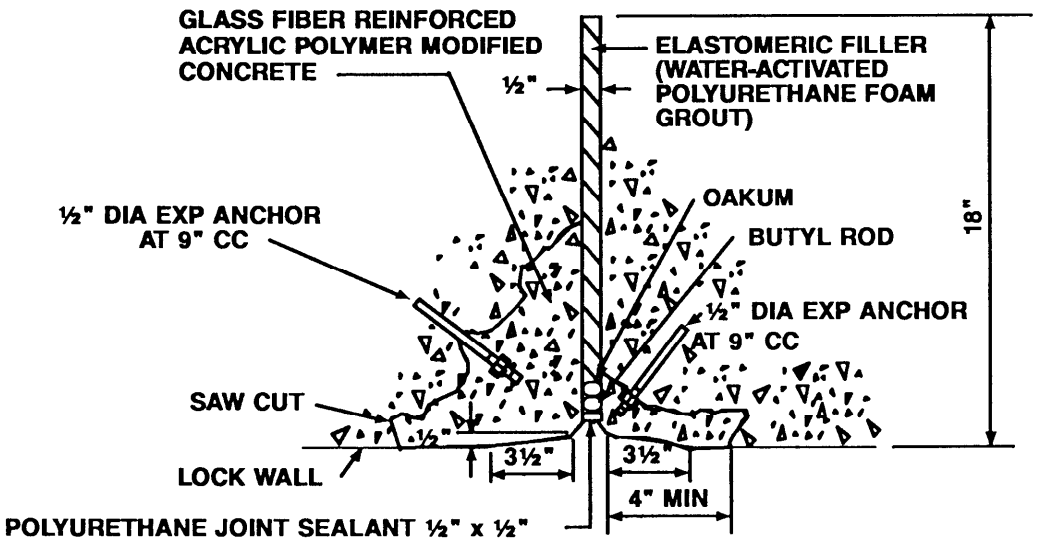

Figure 2. Joint repair detail

Work began with identification and removal of the deteriorated concrete around the joints. Removal areas were identified by visual examination and with sounding hammers. A 1-1/2-in.-deep saw cut was made around the perimeter of the repair area. The cut was made at a 15-deg angle to form a keyway except for the top joint which was cut perpendicular to the face of the wall. The deteriorated concrete was removed with hand-held jackhammers which allowed the operators to "feel" sound concrete when they reached it. The minimum removal depth was 2 in. (Fig. 3).

The existing joint filler, asphalt-impregnated foam rubber secured with nails, was very difficult to remove. Ultimately, an electric chain saw was determined to be the best removal tool.

Mechanical anchors (1/2-in.-diam) were installed on 9-in. centers on both sides of the joints. A stud-type anchor was selected because it would not be loosened if hit by the vibrator used to consolidate the FRAPMC. After the anchors were set, the surface to be repaired was cleaned with brushes and air.

Because the temperatures were well below freezing, special provisions were made to protect the concreting operation. The cement and polymer were stored inside a heated enclosure; the aggregate was stored in a heated, covered stockpile, and the area around each joint was enclosed and heated. The FRAPMC consisted of a modified cement, liquid polymer, 3/8-in.-maximum-size granite aggregate and 2-1/4-in. polypropylene fibers. The cement and polymer were prepackaged units which simplified batching and mixing. Each unit had a volume of 1/2-cu ft to which 30 lb of aggregate and 1 oz of fibers were

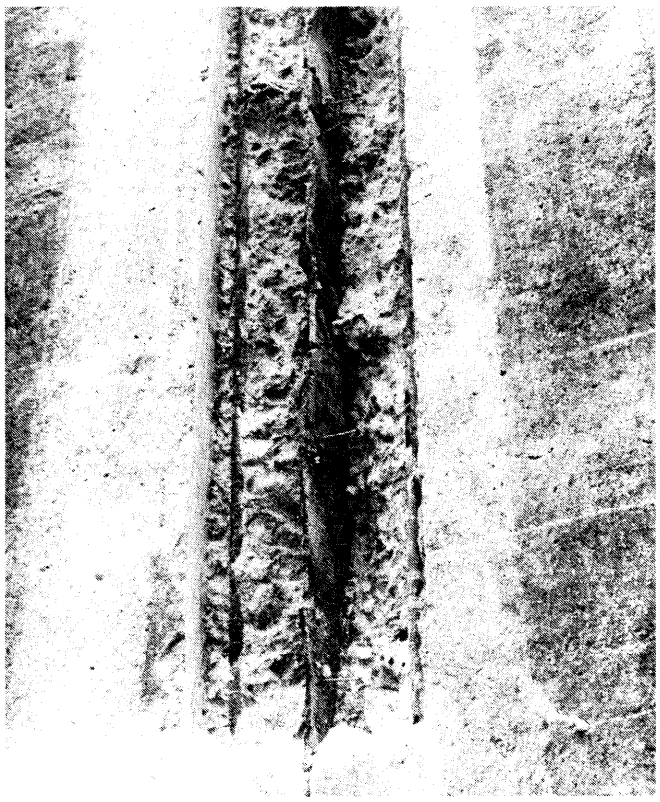

Figure 3. Joint with deteriorated concrete removed

added. Including fibers and aggregate in the mixture necessitated the use of an additional 25 to 30 percent polymer to obtain the desired workability. The resulting mixture was self-leveling and easily placed by being poured into the forms and consolidated by internal vibrators.

Because FRAPMC will adhere to a wooden form coated in form oil, the forms required a 6-mil polyethylene lining. Even with a form-release agent specifically designed for use with acrylic modified concrete, the FRAPMC still bonded to the form if polyethylene was not used. Only 2 hr after placement, the form was removed and used for the next 7-ft lift. This rapid turnaround allowed completion at several lifts of a single joint in one day.

The joint was recessed from the face of the lockwall with a bevel 3-1/2 in. by 1/2 in. and a 45 deg chamfer at the joint edge (Fig. 2). The 1/2-in. expansion joint between monoliths was maintained with gatorboard (a styrofoam core with a thin plastic face on both sides). After the FRAPMC had cured sufficiently for the gatorboard to be removed, the soft styrofoam center was removed and the plastic faces previously coated with form oil released easily. The expansion joint was filled with a water-activated polyurethane foam grout and sealed with a polyurethane joint sealant.

RESULTS: The FRAPMC joint repairs continue to perform well. The same technique was used by the St. Paul District to repair similar spalling at Lock and Dam No. 3 during the 1987-88 winter.

REFERENCE: a. US Army Engineer District, St. Paul, CE. 1985. "Lock and Dam 2, Hastings Minnesota, Concrete Condition Report, Existing Lock and Dam," St. Paul, MN.

b. _____. Undated. "Design Analysis Report for Concrete Rehabilitation and Wall Armor at Lock and Dam No. 2," St. Paul, MN.

c. Dahlquist, Michael S. 1987 (Oct). "Use of Fiber-Reinforced Acrylic Polymer Modified Concrete as Repair Materials at Lock 2," The REMR Bulletin, Vol 4, No. 2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

d. May, James G. and McDonald, James E. 1989 (Aug). "Monolith Joint Repairs: Case Histories," Technical Report REMR-CS-22, US Army Engineer Waterways Experiment Station, Vicksburg, MS.